Wheeler Laboratories, Inc.

A SUBSIDIARY OF HAZELTINE CORPORATION

Box 561, Smithtown, N. Y. 11787

Harold A. Wheeler, President

ANdrew 5-3810

File 466
TL-3
HWR:car

1964 MAY 19

Director, Electronics and Control Division (Code RET)
Office of Advanced Research and Technology
National Aeronautics and Space Administration
Washington, D. C.

Attention: Mr. Roland Chase

Reference: Contract NASw 888

Subject: Development of Macroscopic Optical Waveguide Components - Progress 1964 APRIL.

Gentlemen:

This is the third progress report on the development of macroscopic waveguide components for optical systems being performed for the National Aeronautics and Space Administration (NASA) by Wheeler Laboratories (WL) under contract NASw 888. This report covers the month of April 1964. The overall objectives of the current contract, to be completed by 1964 NOV 28 as described in Ref. 1, are: (1) to determine the factors affecting the design and fabrication of macroscopic waveguide and waveguide components, (2) to investigate specific configurations in order to develop practical concepts for component design, and (3) to undertake actual component fabrication and testing to prove the feasibility of the design concepts.

Work Performed During Current Month.

The initial phase of this program, to be completed 1964 MAY 28, involves the following tasks: (1) an analysis of propagation in dielectric waveguides, (2) a survey and study of material and fabrication techniques required for construction of optical components, (3) experimental testing of the waveguides considered suitable for component fabrication. During this month effort has continued on the above tasks and has been directed to the preparation of an interim technical report.

A. Analysis of Propagation in Dielectric Waveguides.

The analysis of the waveguide theory has been completed and is currently being put into a form suitable for the interim report. In addition to the topics reported previously the following topics have been studied. A "mode chart" for circular dielectric waveguide has been prepared. Curves of guide wavelength at a few typical operating conditions have been prepared for several low order modes of the slab waveguide to determine relative phase velocities for these modes. Graphs of the field amplitudes for several modes have been plotted for both circular and slab configurations. These graphs indicate that, when both the core and cladding fields are considered, the overall field shapes approximate gaussian curves ($\exp -a^2x^2$). Formulas for excitation efficiency have been evaluated assuming gaussian distributions for the exciting and waveguide fields.

B. Survey and Study of Waveguide Construction.

As reported previously, the study of waveguide construction has been divided into three parts: (1) configurations, (2) fabrication techniques, and (3) materials. During April primary effort has been concerned with new configurations. Several types have been studied and materials are being procured. These types include bisected guides, with one metal wall, and solid-core slab and circular guides. An aluminum deposited waveguide plate has been received for the bisected guide.

C. Experimental Testing.

During April, emphasis has been placed on experiments to demonstrate the feasibility of the waveguide operation. The objective of these tests is to compare experimental operation with the theoretical calculations. Sufficiently close agreement between theory and measurement has been obtained with the slab configuration to indicate operation as intended; however some problem areas have been indicated as described below.

The measurements have included tests to determine the relation between the number of modes which may be excited as a function of the spacing and difference in dielectric constants between the core and the cladding. Good agreement with calculations has been obtained and the required difference in dielectric constant for single mode operation has been indicated.

In addition, measurements have been made of the detailed shape of the transverse fields in the waveguide and close agreement with the theory has been obtained. A measured and calculated aperture field pattern for single mode operation is shown in Fig. 1

on a logarithmic scale (in decibels). The calculated field has a cosine shape within the core and an exponential shape in the cladding. On the logarithmic scale, the exponential shape in the cladding is a straight line. This straight-line variation is clearly indicated in the region of the cladding for the measured curve.

Characteristics of the radiation from the waveguide aperture were measured. The dual-lobe patterns expected from higher modes were observed and beam angles were correlated with the theory. Some problems for low-mode patterns were encountered in that spurious radiation from the cladding obscured the measurement of the desired patterns. The problem of suppressing spurious radiation in the cladding region is being studied.

At the end of the reporting period, a new waveguide test fixture, which will hold guides up to six inches long, was completed. Glass flats for this guide are being fabricated.

D. Technical Report.

The interim technical report to cover the first four months of the contract period (Jan. 28 to May 28, 1964) is being prepared. Sections of the draft have been completed during this report period.

E. Conferences.

On April 21 Mr. R. Chase and Dr. H. Plotkin of NASA visited Wheeler Laboratories at Smithtown, N. Y. A brief inspection of the antenna facilities was made and the microwave background was reviewed. In connection with the optical waveguide work, the laser research program at WL and the current waveguide program were reviewed. A demonstration was presented of both single- and multimode operation of a slab waveguide.

Work Planned for Next Month.

The general results of the work performed during May will be included in the interim technical report; it is planned to cover the detailed work in May and June in the next progress letter to be initiated on July 1, 1964. The general topics to be covered during this period include the following.

(1) An experimental evaluation will be made of a bisected-slab waveguide configuration, a solid-core slab configuration, and a solid-core circular configuration.

(2) The pattern range for measurements of radiation is to be modified to automatically record aperture field and radiation patterns.

(3) The tests will include accurate measurement of higher mode patterns, some of which are needed for component design.

(4) Tests will be performed in the newly constructed waveguide box. This fixture will permit the testing of longer waveguide samples and waveguide components and will permit greater precision of location and adjustment of assemblies.

(5) The interim report is planned to be completed.

(6) A review of the work to date and a study of components is to be made to select a component for fabrication. The design of the component is to be initiated.

Personnel.

The work on this project has been carried on by E. R. Schineller, D. W. Wilmot and H. M. Heinemann under the direct supervision of H. W. Redlien. Advice and general direction has been provided by H. A. Wheeler and F. H. Williams.

References.

(1) D. W. Wilmot, R. A. Kaplan, "Development of Macroscopic Waveguide and Waveguide Components for Optical Systems", Wheeler Labs. Report 1139; April 1, 1963.

(2) E. R. Schineller, "Development of Macroscopic Optical Waveguide Components - Progress 1964 February ", Technical Letter No. 1 to NASA, 1964 March 17.

(3) H. W. Redlien, "Development Macroscopic Optical Waveguide Components - Progress 1964 March", Technical Letter No. 2 to NASA, 1964 April 15.

Very truly yours,

Henry W Redlien

Henry W. Redlien
Project Supervisor

Enc. Fig. 1

cc: Roland Chase (24 + 1T)
New Technology Representative Code (ATU) (1)

Wheeler Laboratories, Inc.
Smithtown, N. Y.

File 466
TL-3
HWR:car
640519

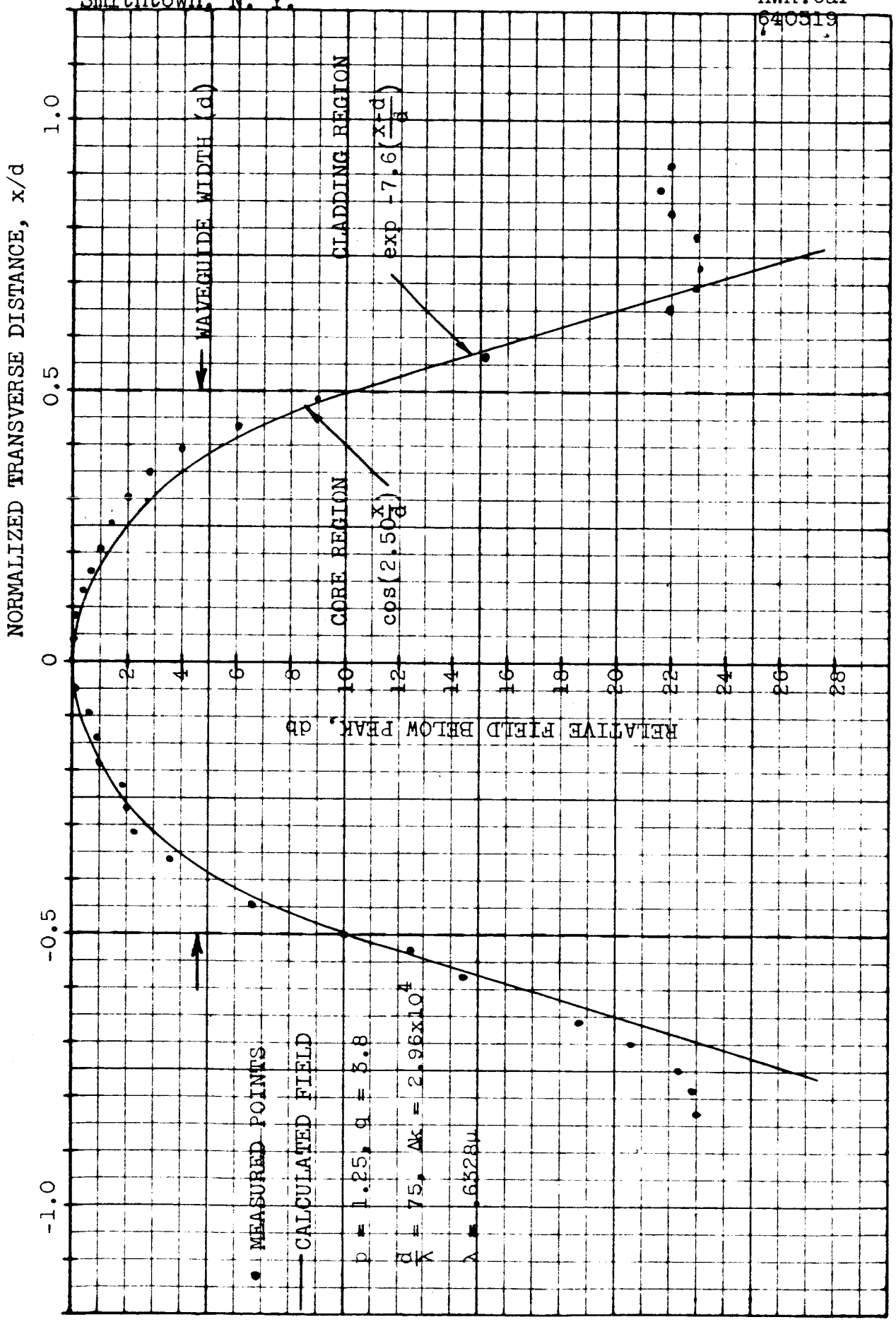

Fig. 1 - Measured and calculated transverse field of fundamental mode.